

Amount of Spawn for Hobby Cultivation of *Pleurotus ostreatus* & Potential New Culinary Mushrooms for the Swedish Market

Mängd ympat mycel vid hobbyodling av *Pleurotus ostreatus* & Potentiella nya matsvampar för den Svenska marknaden

Dylan Wallman



Picture: Dylan Wallman

Självständigt arbete 15 hp
Hortonomprogrammet
Alnarp 2015

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Omfattning: 15 hp

Nivå och fördjupning: G2E

Kurstitel: Kandidatarbete i biologi

Kurskod: EX0493

Program/utbildning: Hortonomprogrammet

Examen: Kandidatexamen i biologi

Ämne: Biologi (EX0493)

Utgivningsort: Alnarp

Utgivningsmånad och -år: januari 2015

Omslagsbild: Dylan Wallman

Elektronisk publicering: <http://stud.epsilon.slu.se>

Nyckelord: *Oyster mushroom, Pleuratus ostreatus, spawn, culinary mushrooms, Ostronskivling, ympmängd, mycel*

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Preface

This study is a BSc thesis made within the study program of Horticultural Science in the Swedish Agricultural University (SLU), Alnarp. I would like to thank my supervisor Malin Hultberg for all the support and encouragement. I would also like to thank Christina Persson (assistant supervisor) at Ecofungi for all the useful information and inspiration. Last I would like to thank Johnny Carlsson at Svampuset that contributed with the grow boxes as well as a lot of information and inspiration.

Alnarp, 2014

Dylan Wallman

Abstract

The present study investigated the effect of different amount of spawn (45g, 90g, 180g) used to inoculate substrate in grow boxes for Oyster mushroom (*Pleurotus ostreatus*) cultivation. It showed that the more spawn used the shorter the time got between inoculation and primordia formation.

This paper also includes a literature study where culinary mushrooms with introduction value to the Swedish market are briefly reviewed with special focus on the aspects of health claims and cultivation methods.

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Introduction

Purpose

The Swedish production and consumption of culinary mushrooms has a great potential both from economic and environmental perspective. Mushroom cultivation can play a great role in using and reusing different waste materials from the agricultural sector, forest sector as well as the industry. Mushrooms could also serve as a substitute for meat consumption since it is a good source of protein. Furthermore there are also several new scientific discoveries of health benefits related to mushrooms, an additional reason to increase the mushroom consumption in Sweden.

The purpose of this study is to try different amounts of spawn used in hobby cultivation of Oyster mushroom (*Pleurotus ostreatus*) in order to make the growboxes (see 'The Growboxes') produced by Svamphuset a better product.

The literature study has been conducted to find mushrooms that could have potential to be sold on the Swedish market. This information could be used by producers (in Sweden or that export to Sweden) or stores if they want to produce or sell new species.

History of Mushroom Cultivation in Sweden

Compared to some of the Asian countries with a long history of mushroom cultivation the Swedish tradition of cultivating mushrooms is quiet insignificant. The Swedish production started in the 1930's with the white button mushroom (*Agaricus bisporus*). In that time the white button mushroom was considered an exclusive product. At first it was cultivated outdoors but the production moved inside to be able to produce all year around. During the 1960's and 1970's the production techniques developed which improved the working conditions for the growers. The better working conditions did not last long because later in the 1970's cheap import from Poland forced most of the Swedish producers out of business. During the 1980's and 1990's some new productions started but the prices continued to fall and a lot of the growers had a hard time to survive financially. Today the Swedish growers are mainly producing mushrooms that are being sold fresh to stores located in the same region as the production. There are about 20 growers and about 50 people working in Swedish mushroom farms today (Tullander, 2012) (Svenska Svampodlarföreningen, 2014).

Background

Oyster Mushroom (*Pleurotus ostreatus*)

The annual consumption of oyster mushrooms for a Swedish person is about 0.02 kg. The total consumption is about 200 tons. Half of the consumed oyster mushrooms are produced in Sweden (there are around five producers) while the rest is imported (Svenska Svampodlarföreningen, 2014).

The oyster mushroom contains β -glucans that can stimulate the growth of colon microorganisms (probiotics) (Synytsya *et al.*, 2009). There are also a lot of studies that shows antioxidant properties of the oyster mushroom.

Life Cycle

On the bottom side of the cap are the gills located. The gills carry basidiums which each carry four basidiospores. Each one of these spores has the potential to start grow into a hyphae and form a primary mycelia. When the primary mycelia meets another primary mycelia of the

same species that it is compatible with, a secondary mycelia starts to grow. It is the secondary mycelia that can produce fruit bodies under the right growing conditions (Kang, 2004).

Growing Environment

Depending on what your cultivation goal is, the growing environment might have different importance. For the hobby grower that just wants to grow for the sake of growing and maybe eat some home grown mushrooms once in a while, optimal growing conditions might not be that important and also very difficult to maintain. In commercial production the case is the complete opposite. The harvest has to be more or less reliable and predictable; this is only possible with controlled environment. Environmental factors that play a role when growing oyster mushrooms include temperature, relative humidity, light, carbon dioxide and acidity of the substrate. Different stages of the mushroom life cycle also require different environmental growing conditions. When the mycelium is colonizing the substrate it is optimal to have a relative humidity of 65-70%, water content of the substrate of 65% and a temperature of 20-25 °C. When the substrate is fully colonized these environmental conditions can be changed in order to induce pinning (beginning of mushroom formation). The mycelium will recognize changes in the environment and start produce fruit bodies. The pinning induction can be done by decreasing the temperature by approximately 10 °C (cold chock), increasing the humidity to 80-95% and increase the amount of light. It is not always necessary to do all the things but in a standardized production it is preferred to make sure the pinning gets properly induced.

It is also important to have some sort of disease control. In mushroom cultivation prevention of contamination is the most efficient way to control diseases. Hygiene when handling the cultures as well as sterilization of substrates and tools are important (Kang, 2004)

Spawn

Production of spawn for oyster mushroom cultivation is more or less divided into two parts. First comes the initial mycelium growth that usually takes place on agar. The agar that normally is placed on petri dishes can be inoculated with spores (sexual reproduction), a piece of the fruit body (asexual reproduction) or a piece of the mycelium (asexual reproduction). There are many different ways to give nutrition to the agar but Malt Extract Agar (MEA) and Potato Dextrose Agar (PDA) are two methods that work good for Oyster Mushrooms. After inoculation the mycelium will colonize the agar. This mycelium can then be divided and used to inoculate grain spawn. Rye, wheat, milo, sorghum, corn and millet are some of the materials that can be used as spawn substrates. It is also possible to use sawdust but is more commonly used to inoculate outdoor cultivation in logs. The spawn is used to inoculate the substrate used for fruit body formation. Different rates of spawn in the growing substrate will result in different colonization times for the mycelium as well as different yields; below some research on how different spawn rates affect these things will be presented. During the process of spawn preparation good hygiene and sterilization routines is essential. For the hobby grower good knowledge about how to keep things sterile and what phases extra care is needed can be enough but for the commercial grower it is usually necessary to use a special clean room that are kept as sterile as possible (Stamets, 1993).

There are three studies that look at the spawn rate for Oyster Mushrooms. Two of them investigate *Pleurotus cornocupiae* which is also known as the Golden Oyster Mushroom. It is not the same species as the 'normal' Oyster Mushroom *Pleurotus ostreatus* but it is a close relative which might make the research relevant also for *P. ostreatus* cultivation. The third study looks at different spawn rates of *P. ostreatus*. In the first study they grew *P. cornocupiae* on a mix of pasteurized cottonseed, chopped wheat straw and ground limestone. They spawned the substrate at different rates (1.25%, 2.5%, 3.75% and 5% wet weight). The

replicates that used 5% spawn rates had significantly the highest yields and there was a positive correlation between spawn levels and yields. There was also a negative correlation between spawn rate and days from inoculation to initial fruit body formation. When the spawn rate increased the days to initial fruit body formation decreased. A spawn rate of 3.75% had a 7 days shorter period to initial fruit body formation compared to a spawn rate on 1.25% (Royse, 2002). The second study that also investigated spawn rates on *P. cornucopiae* also concluded that the spawn rate has a positive effect on the yields. The size of the mushrooms was not affected by the spawn rate but the time from inoculation to initial fruit body formation was reduced with 4.4 days when the spawn rate went from 5% to 2.5% (Royse *et al.*, 2004). The study that investigates spawn rates on *P. ostreatus* studied spawn rates for 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 g spawn/kg substrate (dry weight). The spawn substrate was sorghum and the substrate wheat straw. The best yield was obtained with 70 g spawn/kg substrate (DW). The number of fruiting bodies was increasing with the amount of spawn and the fastest time to initial fruit body formation was obtained with 70g spawn/kg substrate (DW) (Bhatti *et al.*, 2007).

Substrate

In nature Oyster Mushrooms grows on broad-leaf hardwoods where the main sources of nutrients are cellulose, hemicellulose and lignin. When choosing substrate for cultivation the right amount of organic (C: N ratio) and inorganic (micro and macro nutrients) has to be put together. Most of the substrates used for cultivation need supplemented nitrogen. In order to add this extra nitrogen wheat or rice bran can be added to the substrate. Since *P. ostreatus* uses lignin and cellulose to grow, there is a wide range of materials it can grow on. There is also plenty of different agricultural waste materials that suits as substrates for cultivation. This makes *P. ostreatus* a good candidate for cultivation in most countries since the substrate can be adapted to the agricultural wastes of the region (Pope, 2004).

In order to compare different substrate efficiencies with each other within and between different studies a standard equation is used. This equation gives a percentage value called 'biological efficiency' (BE) and is calculated from the fresh mass of produced mushroom divided by the dry mass of substrate used times 100.

$$P = \frac{\text{mushroom dry mass}}{\text{dry mass of initial substrate}} \times 100$$

$$BE = \frac{\text{mushroom fresh mass}}{\text{dry mass of initial substrate}} \times 100$$

There are a lot of research papers on different substrates for cultivation of *P. ostreatus*. Some are comparing the normal substrates used while others are trying different agro wastes to look for new ways to use waste materials. It is also important to have in mind that different strains of *P. ostreatus* might grow differently on different substrates and that different growing conditions could make BE between different studies a bit misleading. In this section a few selected research articles about substrates will be presented. Since this paper focuses on Swedish production substrates that are not available or with potential to become available in Sweden are left out. In Sweden there are different cereals such as wheat, oat, rye and barley (Jordbruksverket, 2014) as well as forestry that might give tree residues that could contribute as sources for substrates. *P. ostreatus* does not grow well on evergreens and prefer wood material from hardwoods (Personal communication Christina Persson, Ecofungi).

A study conducted in Pakistan compares different compositions of saw dust, leaves and wheat straw. The study concludes that sawdust gives the highest BE (biological efficiency) of 64.69% while wheat straw gives a BE of 57.85%. The substrate made of pure leaves gave a BE of 21.05% (Shah *et al.*, 2004). Another study that looks at a bit more exotic materials also gives sawdust a BE (61.04%) close to the BE (64.69%) mentioned about sawdust in the report from Pakistan (Obodai *et al.*, 2003).

There is a study that includes waste paper as a substrate. Although it was the least successful of the three tested substrates with a BE of 53.00% it is still interesting since it might be available from the Swedish paper industry. Except for the waste paper the study also looked at wheat straw and wood chips combined with wheat straw. The wood chips with wheat straw was more successful (BE 78.00%) than wheat straw alone (BE 63.00%) (Sofi *et al.*, 2014).

Another study with possible relevance for Swedish production is looking at spent beer grains as a substrate. Different types of spent beer grains were tried with addition of different grains. The most successful combination gave a BE of 19.1% and was composed of spent beer grains and 45% wheat bran (Wang *et al.*, 2001).

Material & Methods

Test of Three Amounts of Spawn

The Growboxes

The study was conducted on grow boxes provided by Svamphuset (<http://www.svamphuset.com>). The grow box is made of cardboard and looks like a small house. Cardboard is used for the appearance but it also serve to keep humidity levels high during the fruit body growth (during this phase the house is sprayed with water twice a day). In the cardboard 'house' a plastic bag containing the substrate is placed. The plastic bag has ventilation strips that are designed for air exchange without the possibility of letting in contaminations. The cardboards house is designed so that 'windows' can be opened in the 'walls' and on the 'roof'.

The substrate that is used in the grow boxes consists of rape and wheat straw but the exact recipe is kept secret by the manufacturer. When the cultivation is started water is boiled, cooled down and applied in the plastic bags together with the dry substrate pellets that soaks up the water and gets the right humidity for the mycelium to grow. During this phase the 'windows' are closed to keep a dark environment for the mycelium to grow in. After some days it is possible to open one of the 'windows' to keep track of the mycelium development. It then takes a bit more than two weeks until primordia (see Figure 1) (beginning of fruit body formation) starts to appear. When this happens it is time to open all the 'windows' of the cardboard house (see Figure 2), cut crosses in the plastic bags where the 'windows' are located at start to spray the 'houses' two times every day. The mushrooms will start to grow out of the 'windows' and in a few days there will be mushrooms ready to harvest (see Figure 3).



Figure 1. Primordia (initiation of fruiting phase). Picture: Dylan Wallman



Figure 2. Cardboard box, spawn bag, and substrate bag. Picture: Dylan Wallman



Figure 3. Ready to harvest. Picture: Dylan Wallman

The Spawn

The spawn (see Figure 4) was provided by Ecofungi (www.ecofungi.se). The substrate used for the spawn is a mix of different materials. The main ingredient is sawdust from hardwoods since the oyster mushrooms does not grow on sawdust from evergreens. 10% of crushed wheat (Swedish: vetekli) is also mixed in to add nitrogen for a faster growth. When the mycelium breaks down the lignin in the sawdust acids are being released which lowers the pH. To compensate for the lower pH 1% lime or gypsum is added. The amount of water that should be added to keep the right moisture of the substrate is 63-65% of the substrate weight (Personal communication Christina Persson, Ecofungi)



Figure 4. Spawn bag. Picture: Dylan Wallman

Growing Environment

Since the product is sold to households for hobby growing an environment as similar to a 'normal' Swedish room climate was used. This was done in a way to minimize environmental differentiation between the different experimental units. The light was provided from above in a way that gave all the experimental units the same amount of light. The experiment was also designed in a way that gave the same treatment in the other factors as well. The temperature was varying in a normal manner for a Swedish household and within the requirements for cultivation of oyster mushrooms.

Experimental Design

The study consisted of 3 different amounts of spawn: 45g, 90g and 180g. Each category of spawn was replicated 6 times. The positions of the experimental units were randomized in a 3x6 formation. The days from inoculation to primordia formation were counted. After the primordia formation the boxes were opened ('windows' opened and plastic bags cut open) and the fruit bodies could expand. When the fruit bodies reached the right ripening stage and were harvested and the yields were measured (fresh weight). The fruit bodies were ready to harvest when the borders of the caps were straightening out (see Figure 5).



Figure 5. Harvested mushrooms. Picture: Dylan Wallman

Literature Study Method

The literature study was conducted by searching for scientific articles on Google Scholar and looking for information in books. Most of the general information together with cultivation methods, substrates and food applications comes from books while information about health studies come from scientific articles.

The species was selected based on production aspects – they have to have cultivation methods similar to mushrooms already cultivated in, or imported to Sweden so that cultivation can be adapted easily. Culinary value has also been taken into consideration – the mushroom has to be used culinarily somewhere in the world. There is of course no guarantee that Swedish consumers have the same food preferences as other cultures but I still consider it easier to adapt a new mushroom species as food if there is other people already eating it compared to a species that has never been used as food before. Research on health benefits related to the mushrooms species has also been included since this might promote the adaption of the new species by Swedish consumers.

Results

Results for the Different Amounts of Spawn

The number of days from inoculation to primordia formation differed between the different treatments. The more spawn that was added the shorter the time was until primordia formation. The shortest time was 13 days and was obtained with 180g spawn and the longest time was 20 days and was obtained with 45g of spawn.

Table 1. Mean days to primordia

Trial	Mean days to primordia	Stdev
45g	19,5	0,836660027
90g	16,16666667	1,169045194
180g	13,33333333	0,516397779

The highest yields and shortest time for fruit body formation was obtained with the highest amount of spawn (180g). The yields were lower with lower amount of spawn.

Table 2. Mean weight

Trial	Mean Weight	Stdev
45g	156,5	59,52730466
90g	211,8333333	66,44521553
180g	321	24,05826261

The days from primordia to harvest did not have any correlation to the amount of spawn but during the trial external factors changed and when looking at the results for the yields it should be taken in to consideration that a lot of the mushrooms were starting to dry before they got harvested, because of this some of the yield values is not really representative. The days from primordia to harvest might also be misleading since the mushrooms from the trials with 45g was starting to dry out and it was harder to recognize a certain point of development for harvesting (more about this in the discussion/conclusion section).

Culinary Mushrooms with Introduction Value to the Swedish Market

Auricularia spp.

Introduction

Auricularia spp is a genus of mushrooms of around 10 species. The most popular ones are *A. auricularia* and *A. polytricha*. Common English names for the genus are Wood Ear, Jew's Ear, or Ear Fungus. It is considered to be the first cultivated mushroom, already cultivated A.D. 600 in China. The fruit bodies of the mushroom looks like human ears and have a rubbery like flesh. In China it is very popular to use the mushroom for making soups and it is one of the most popular mushrooms on the Chinese market (Chang and Miles, 2004) (Stamets, 1993).

Health

There is a study that investigated at the antioxidant properties of extracted polysaccharides from *A. auricularia*. In the study they mixed different amount of extracts with flour and then baked bread out of it. The bread containing the extract showed higher antioxidant properties than the bread without the extract. The antioxidant properties also increased with the amount of extract incorporated in the flour (Fan *et al.*, 2007). Another study conducted on mice showed that polysaccharide extract from *A. auricularia* have antioxidant properties and a hypolipidemic effect in vivo (Luo *et al.*, 2009).

Cultivation

The cultivation methods of *Auricularia spp* are very similar to the cultivation methods of

Lentinula and *Tremella*. It can be grown in polypropylene bags or bottles designed for mushroom cultivation or plugged into wood logs. When cultivated in bags or bottles the substrates used are the same types of sawdust compositions that are typically used for *Leninula* cultivation (Stamets, 1993).

Conclusion

Since the cultivation techniques and substrates are very similar to mushrooms that are already cultivated in Sweden, *Auricularia spp* could be a good candidate for Swedish production. The shape physical appearance (look like a human ear) might be a disadvantage in the marketing but could possibly be turned into something beneficial as well. Its popularity in China, (although great cultural differences) together with its antioxidant properties could also be seen as a possible success indicator for the Swedish and European market, especially in the long run.

Volvariella volvacea

Introduction

This mushroom also has its cultivation history from China dating back to 1822 but the cultivation much likely started even before that. It's the mushroom that, under the right growing conditions, has the fastest spawn to harvest time (8 to 10 days) of all cultivated mushrooms. In English it is commonly called straw mushroom or paddy straw mushroom (Chang and Miles, 2004).

Health

There is a study that investigated the antioxidant properties and antitumor activity for both ascites and solid tumors in mice using an aqueous ethanolic extract from the mycelium of *V. volvacea*. The study concluded that the extract had significant antioxidant activity as well as significant antitumor properties (Mathew *et al.*, 2008).

Cultivation

A great variety of substrates can be used as spawn media for *V. volvacea*. Grains (Rye, Sorghum, and Wheat), rice straw, used tea leaves, cotton waste, manure-husk (from lotus seeds), and a lot of other waste materials has been used for cultivation of *V. volvacea*. The mushrooms are produced in boxes (more similar production style with white button mushroom than oyster mushroom) and require a bit higher temperature compared to most other cultivated mushrooms (Chang and Miles, 2004).

Conclusion

Although *V. volvacea* is more commonly cultivated on more exotic substrates (e.g. rice straw) in the current production regions it is also possible to cultivate it on substrates available in Sweden such as Rye and Wheat. The health benefits related to the species together with the fact that the mushroom is very popular in its home regions and easy to apply in various dishes might make it a good candidate for Swedish production and the Swedish market.

Flammulina velutipes

Introduction

F. velutipes is a popular mushroom in China, Japan, and South Korea where also the main production is located. The mushroom is usually produced for the gourmet market or for tonic production (Chang and Miles, 2004). In English is it commonly called Enoki Mushroom or Enokitake as it is called in Japan.

Health

A study on the *F. velutipes* effect on blood serum cholesterol levels in rats showed that the rats eating the mushroom fibers instead of cellulose powder showed significantly lower LDL-cholesterol levels (Fukushima *et al.*, 2001). LDL-cholesterol is also known as the "bad cholesterol" (Fitday, 2014).

Cultivation

F. velutipes can be cultivated on woodlogs but in commercial production sawdust from hardwoods are preferred but it is also possible to use a mixture of sawdust from hardwoods and conifers. Cold (3-5 °C) is required for the mycelia to produce fruit bodies. This is usually a limiting factor for production, especially in developing countries.

Conclusion

Different types of sawdust are available in Sweden which makes it possible to produce this mushroom. The cold factor for fruit body production might complicate the production a bit but in Sweden the problem could possibly be solved in a much cheaper way compared to countries with a warmer climate, especially during the cold period of the year. Suggestively the mushroom could be marketed as a winter product. The name (Enokitake) shares similarities to the better known Shiitake mushroom which might be beneficial in the context of marketing.

Hypsizygus ulmarius

Introduction

H. ulmarius, also known as the elm oyster shares as the name indicates a lot of its morphology with the Oyster mushroom. The fruitbody has both better flavor and texture than the Oyster mushroom (Stamets, 1993).

Health

Polysaccharides from *H. ulmarius* showed to have significant antitumor activity in mice. The mice treated with polysaccharides from *H. ulmarius* solved in water had an inhibition ratio of 80% compared to the control group (Krasnopolskaya *et al.*, 2008).

Cultivation

This mushroom can be cultivated on sawdust mixed with rye, rice or wheat bran to fulfill the nutrients required for a proper harvest. The cultivation containers are similar to the ones used for the Oyster mushroom (Stamets, 1993).

Conclusion

The fact that this mushroom is so similar to the Oyster mushroom that is already on a good way to have an established role on the Swedish market might make it a bit superfluous. It could also be seen as an advantage that a similar mushroom already is there and *H. ulmarius* could possibly be well suited for a niche market.

Hypsizygus marmoreus

Introduction

H. marmoreus also shares a lot of similarity with the Oyster mushroom. In Japan it is usually called "Hon-shimeji" and in the USA it is called "Shimeji" (Stamets, 1993).

Health

A study on mice showed that polysaccharides from *H. marmoreus* have antitumor activity (Motoi *et al.*, 2003).

Cultivation

This mushroom is also possible to cultivate in a similar style as the Oyster mushrooms with sawdust from a range of different hardwoods as substrate.

Conclusion

I consider the cultivation possibilities and market opportunities for this species similar to *H. ulmarius*. Since the fruit bodies are so similar to the Oyster mushroom the appearance is not too alien for Swedish consumers which I consider positive but as mentioned for *H. ulmarius* it might be a bit superfluous to add a mushroom so similar to the Oyster mushroom to the broad market.

Pholiota nameko

Introduction

This mushroom is also known as the Nameko mushroom. It is a very popular mushroom for culinary use in Japan. Unprepared this mushroom has a thick slime covering the cap but it disappears when the mushrooms are cooked. It is supposed to be a very tasty mushroom that can be prepared in different ways (Stamets, 1993).

Health

A study that were investigating the hypolipidemic effects of polysaccharide isolated from *P. nameko* showed that it could significantly suppress the development of hypolipidemia in rats (Li *et al.*, 2010).

Cultivation

This mushroom can be cultivated on nutrient supplemented sawdust from hardwoods (Stamets, 1993).

Conclusion

The thick slimy cover of this mushroom when not cooked might be a problem if the mushroom is going to be introduced to the Swedish market. It might be a better option to sell it dried or somehow cooked already. Hypolipidemic properties might attract health aware customers and *P. nameko* might be better suited for a smaller niche market such as health oriented or organic stores.

Grifola frondosa

Introduction

This mushroom that is also known as Maitake does not have a long history of cultivation. It's first in the mid-1980s this mushroom started to be cultivated in Japan. It is considered to have a very nice taste and medicinal properties which has led to a rapid increase in production and sales (Chang and Miles, 2004).

Health

One study looked at the immune response in mice. The mice were fed with D-fraction, a polysaccharide from *G. frondosa*. The study concluded that the polysaccharides may enhance host defense against pathogens as well as protect healthy individuals from infectious diseases. It also reported that the polysaccharides elicit antitumor activity (Kodama *et al.*, 2004).

Another study showed that a methanol extract from the Maitake mycelium had scavenging effects on hydroxyl radicals which indicates antioxidant properties (Mau *et al.*, 2004).

Cultivation

G. frondosa can be cultivated in bottles, bags or in beds. The mycelium grows on nutrient supplemented (rice and wheat bran) sawdust from hardwoods. This species requires more air than other species and it is therefore important to make sure that the substrate does not get too compact (Chang and Miles, 2004).

Conclusion

The fact that this mushroom is very popular in Japan (although cultural differences) together with all the positive results in health research might make this mushroom a good candidate for the Swedish market. The name Maitake which shares similarities to the name Shiitake might have a positive effect on the marketing since it might make the Maitake being perceived as a bit less alien in the ears of the Swedish consumers. The production does not differ too much from other mushrooms that grow on sawdust and it should not be too hard for any producer already growing mushroom on sawdust to add the Maitake in their production.

Hericium erinaceus

Introduction

In Chinese the *H. erinaceus* is called Houtou which means monkey head mushroom. It was domesticated by scientists at Shanghai Agricultural Academy of Science. It is considered to be a very tasty and delicious mushroom (Chang and Miles, 2004). The mushroom looks more like a big white beard than a typical mushroom.

Health

A study conducted on rats concluded that the rats fed with extract from *H. erinaceus* had significantly lower elevation in blood glucose level compared to the control group. There was also a significant difference between the different doses (100 mg/kg bw, 20 mg/kg bw) on blood glucose, serum triglyceride and total cholesterol levels (Wang *et al.*, 2005).

There is another study that is very interesting especially since it is conducted on humans. The study tested the effect of *H. erinaceus* on older Japanese people diagnosed with mild cognitive impairment. In the study they concluded that oral administration of *H. erinaceus* significantly increased the test-persons cognitive functions and they also improved during the period of regular intake. After the intake finished their cognitive functions reduced again (Mori *et al.*, 2009).

Cultivation

This species can grow on different agricultural waste materials and is possible to grow on nutrient supplemented (e.g. rice bran, sucrose, gypsum) sawdust in plastic bags (Chang and Miles, 2004).

Conclusion

H. erinaceus does not really look like a traditional mushroom which might be a disadvantage on the Swedish market. It is possible that the situation is the complete opposite as well; its appearance could also be positive since it looks a bit exotic and differs a lot from the other mushrooms on the Swedish market. The health benefits related to this species is also very promising, especially the study that shows a reduction in mild cognitive impairment which is related to dementia and Alzheimer might attract older people to start consuming it. This mushroom is also suited for cultivation for producers already producing other species growing on sawdust.

Discussion / Conclusions

Change in the Environment of the Trial

During the trial the environment changed which created an environmental difference between the experimental units. This was because the fruit body formation was started directly after primordia formation which occurred at different times for the different treatments. Some of the mushrooms started to dry out before they were ready to harvest. This drought made the mushrooms weigh much less during harvest and the measured yield was not really fresh weight but something in between dry and fresh weight.

This problem could have been avoided by choosing to also measure dry weight of the mushrooms but since the first yields were already harvested, measured in fresh weight and discarded it was already too late to measure all the samples in dry weight. The reason why the mushrooms started to dry is unknown. It is possible that since the climate got colder outside the house the relative humidity inside the house was sinking. It is also possible that the temperature in the room increased but since neither the humidity or the temperature was recorded on regular basis it is difficult to tell.

When looking at the results for the yields and days from primordia to harvest it is important to consider these changes in the environment which makes it difficult to conclude correlations between spawn rate and yields as well as growth speed for the mushrooms. Although it might be difficult to draw conclusions about spawn rate and yields and the speed of fruit body formation the data can still be useful. The trial was taking place in 'normal' house conditions which makes all the environmental changes possible for anyone else using this product. By using a higher amount of spawn the cultivation might be more protected against drought. The material used for spawn might be less sensitive to drought and the faster growth of the fruit body give a shorter time when the drought can occur. This product is also supposed to be sprayed twice a day to keep the humidity for the mushrooms, if the time of fruit body formation is shorter there is less time for the grower to forget spraying the mushrooms. It might not be the fault of the producer of the product if the cultivation is neglected but the grower might prefer to blame the product rather than himself and then it might be better for the producer to make a product that is as easy to take care of as possible. It might be a good idea to write that the grow boxes might need to be sprayed more than twice a day or to add a transparent plastic bag to put around the grow boxes in order to keep the humidity level higher.

Yields

The yields increased with the amount of spawn used. Although the yields were affected by the change in the environment which caused some of the samples to dry there is other trials that has showed a correlation between the amount of spawn and the yields (Royse, 2002). If the spawn has a positive effect on the yields might depend on the nutritional value of the spawn compared to the nutritional value of the substrate. If the yields differs a lot between the different treatments and if the yields actually increase with a higher amount of spawn it might be a good idea to increase the spawn rate to create a more attractive product. The consumer might compare the amount of mushrooms and the price to the price of the mushrooms in the store which makes the amount of yield rather important.

Days from Primordia to Harvest (Time of Fruit Body Formation)

The trial did not show any correlation between the amount of spawn and the time for fruit

body formation. It is very likely that the time for fruit body formation were affected by drought since it also got more difficult to decide at what moment to harvest the mushrooms. One of the studies mentioned in the spawn section found a correlation between spawn rate and the time for fruit body formation where 60-100g spawn/kg substrate (DW) gave the shortest fruit body formation and then the time increased when the amount of spawn decreased (Bhatti *et al.*, 2007). Taking into account that the time of the fruit body formation is a period where the cultivation is exposed to external 'threats' such as drought it might be good to try to shorten this period to make the product more reliable and easy to use. The same principle as mentioned in the yield discussion applies here, the easier the product is to use the more attractive it might be for the home grower. To get a proper harvest or not might be the underlying factors in the decision to buy the product again or recommend it to other people.

Days from Inoculation to Primordia Formation

The days from inoculation to primordia formation showed a clear correlation to the amount of spawn used. The shortest time (13 days) was obtained with 180g spawn and the longest time (20 days) was obtained with 45g spawn. The time from inoculation to primordia formation is essential since this is the time when the mycelium is competing with possible contaminations. Even if other microorganisms might not take over the substrate it is still a competition about the nutrients and in case of a contamination that spreads though the substrate a faster mycelium growth gives the mushroom a bigger advantage in the competition. For the home grower a shorter time in general might be positive just because the waiting period is shorter.

Conclusion New Species

There are a lot of new species that has good potential to be successful on the Swedish market. Health benefits such as antioxidant properties as well as positive effects on the blood cholesterol together with good taste should be appealing to the Swedish consumers. Most of the new species also has a good potential to be produced in Sweden or by producers that are exporting to Sweden. Most of them require similar growing techniques and materials as mushrooms that are already sold here. The introduction of the new species might take time but it is difficult to find any reason why these new mushrooms should not be found in the grocery stores in the future.

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